Reverse total shoulder arthroplasty for massive irreparable rotator cuff tears in patients younger than 65 years old: results after five to fifteen years

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Abstract: BACKGROUND: The role of reverse shoulder arthroplasty (RTSA) in the relatively young individual is currently unclear. Our study evaluates the midterm to long-term results of RTSA for patients aged younger than 65 years with pseudoparalysis secondary to massive irreparable rotator cuff tears, with or without arthritis. METHODS: Between 1997 and 2006, 46 RTSAs (41 patients) were performed. Mean age was 60 years (range, 46-64 years). At the latest follow-up, 5 patients had died and 1 was lost, leaving 35 patients (40 shoulders) with a mean follow-up of 93 months (range, 60-171 months). RESULTS: The mean relative Constant score increased from 34% to 74% ($P < .0001$) and the subjective shoulder value improved from 23% to 66% ($P < .0001$). Significant improvements were seen in active forward elevation (72° to 119°), pain scores, and strength ($P < .001$). One or more complications occurred in 15 shoulders (37.5%), with 6 failures (15%) resulting in removal or conversion to hemiarthroplasty (3 with infection, 3 with glenoid loosening). Ten shoulders (25%) underwent partial or total component exchange, conversion to hemiarthroplasty, or removal. Of the 15 patients who developed complications, 9 did not require prosthesis removal or conversion and functional outcome and subjective shoulder value were similar to those with no complications ($P > .4$). CONCLUSION: RTSA in younger patients provides significant subjective improvement and substantial gain in overall function, which is maintained up to 10 years. Although the complication rate is high, most can be treated successfully without compromise to clinical outcome. However, it is imperative that the high complication rate is explained to patients, with the risks and benefits carefully considered.

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Reverse total shoulder arthroplasty for massive irreparable rotator cuff tears in patients less than 65 years old – results after 5 to 15 years

RUNNING TITLE:

Reverse shoulder arthroplasty in younger patients

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ABSTRACT

Background:

The role of reverse shoulder arthroplasty (RTSA) in the relatively young individual is currently unclear. Our study evaluates the mid to long-term results of RTSA for patients less than 65 years with pseudoparalysis secondary to massive irreparable rotator cuff tears with or without arthritis.

Methods:

Between 1997 and 2006, 46 RTSAs (41 patients) were performed. Mean age was 60 years (range, 46-64). At latest follow-up, 5 patients had died and 1 was lost, leaving 35 patients (40 shoulders) with a mean follow-up of 93 months (range, 60-171).

Results:

Mean relative Constant score increased from 34% to 74% ($p<0.0001$) and subjective shoulder value (SSV) improved from 23% to 66% ($p<0.0001$). Significant improvements were seen in active forward elevation (72° to 119°), pain scores and strength ($p<0.001$). Fifteen (37.5%) shoulders had one or more complication with 6 (15%) failures resulting in removal or conversion to hemiarthroplasty (3 infection, 3 glenoid loosening). Ten (25%) shoulders underwent either partial or total component exchange, conversion to hemiarthoplasty or removal. In patients who developed complications that did not require prosthesis removal or conversion (9/15 patients), functional outcome and SSV were similar to those with no complications ($p>0.4$).

Conclusion:

RTSA in younger patients provides significant subjective improvement and substantial gain in overall function, which is maintained up to 10 years. Although the complication rate is high, most can be treated successfully without compromise to clinical outcome. However, it is imperative that the high complication rate is explained to patients, with the risks and benefits carefully considered.

Key words:

reverse shoulder arthroplasty, cuff tear arthropathy, irreparable rotator cuff tear, pseudoparalysis

Level of Evidence:

Level IV study – Case series with no comparison group, Treatment study

INTRODUCTION

Modern reverse total shoulder arthroplasty (RTSA), which was introduced by Grammont, can significantly improve the function of patients with painful pseudoparesis secondary to a massive irreparable rotator cuff tear.[2; 4; 9; 17; 29; 30] Recently, with increasing biomechanical knowledge and clinical confidence, the indications for RTSA have expanded and it has become an accepted option for the treatment of irrecoverable rotator cuff damage in the presence of a functioning deltoid muscle.[10; 20; 25; 29; 31]

However, the complication rate of RTSA is significantly higher than that of conventional shoulder arthroplasty and the success of this procedure depends on appropriate indications and careful patient selection.[5; 15; 32] Furthermore, its longevity is somewhat unclear, with only few studies having reported long-term survivorship data.[9; 18] Currently, it appears that after eight to ten years the clinical results deteriorate despite the absence of radiographic evidence of prosthetic failure.[9; 18] Hence, most authors advocate that RTSA should be used with care in younger patients and in those with high functional demands.

To date, the management of the relatively young and active patient with debilitating rotator cuff dysfunction, not amenable to conservative or alternative surgical methods, remains challenging and controversial. Many joint-sparing treatment options exist, such as physical therapy, corticosteroid injection, arthroscopic debridement and muscle tendon transfers, however these may fail to reliably restore shoulder function and freedom from pain.[8; 13] Hence, the dilemma arises as to whether the RTSA reliably yields the desired improvements in such situations and whether the increased quality of life provided outweighs the risks of complications and early revision surgery.

The use of RTSA has generally not been recommended in patients younger than 65 years of age and as such, there are no studies in the current literature reporting the long-term clinical outcome in younger patients. Therefore, the aim of this present study was to evaluate the mid to long-term clinical and radiological results of RTSA performed in patients younger than 65 years of age for massive irreparable rotator cuff tears with or without glenohumeral arthritis.

MATERIALS AND METHODS

Patients

Between May 1997 and November 2006, forty-six reverse total shoulder arthroplasties were performed in forty-one patients all of whom were less than sixty-five years of age at the time of surgery. The indications were painful pseudoparesis (inability to elevate the arm above 90° in the presence of free passive elevation) secondary to a massive irreparable rotator cuff tear, with or without glenohumeral arthritis. In all patients, prior conservative treatment had failed. The rotator cuff was considered irreparable if pseudoparalysis was chronic, the acromiohumeral distance was < 6mm on plain anteroposterior radiographs in neutral rotation or if there was fatty infiltration of the supraspinatus and infraspinatus muscles greater than stage two according to Goutallier. Only patients with a minimum of five years (sixty months) clinical follow-up were included.

There were twenty-four males and seventeen females. The mean age at the time of surgery was sixty years (range, forty-six to sixty-four). The dominant shoulder was involved in thirty-six cases (78%) and five patients had bilateral surgery. At the time of latest follow-up, five patients had died with less than five years of clinical follow-up, all of whom had no documented complications with regards to their shoulder surgery. Only one patient was lost to follow-up before five years. This left thirty-five patients (forty shoulders) for inclusion in this present study with a mean follow-up period of 93 months (range, 60 to 171).

Twenty-one shoulders demonstrated no radiological evidence of glenohumeral arthritis, corresponding to stage 1 to 3 disease according to the Hamada-Walch classification for massive cuff tear arthritis.[19; 28] There were nineteen shoulders that had developed glenohumeral changes, thus representing Hamada-Walch stage 4 and 5 (Table 1).[19; 28]

Seventeen patients had not had any previous surgery on their shoulder (Group A), whereas twenty-three patients had undergone at least one previous operation (Group B). Of those who had no prior surgery, there were six shoulders with no glenohumeral arthritis and eleven shoulders with glenohumeral degeneration. In the operated group, eight shoulders had glenohumeral arthritis and fifteen shoulders did not. Within this group, seven patients had undergone more than one operation on their shoulder prior to reverse total shoulder arthroplasty. The number and details of the previous operations are displayed in Table 2.

Surgical technique

All patients were operated on in the beach chair position and a deltopectoral approach was utilized in all cases. The surgical technique for implantation of the reverse total shoulder arthroplasty was performed according to the method previously described by Werner *et al* (2005).[30] The Delta III™ Reverse shoulder arthroplasty (Depuy, France) was used in thirty-two cases (80%) and the Anatomical Shoulder™ Reverse (Zimmer, Winterthur, Switzerland) in eight cases (20%). Twenty-nine (73%) humeral stems were cemented with gentamicin-impregnated cement (Palacos, Lucerne, Switzerland) and eleven (27%) were uncemented. The size of the glenosphere was 36mm in thirty-six cases (90%), 40 mm in three cases (8%, all Anatomical™) and 42mm in one case (2%, Delta III™). In the Delta III™ shoulders, a standard lateralized humeral polyethylene cup was used in all patients. In the Anatomical™ shoulders, all patients received a +6mm medialized offset humeral cup. Two patients presented with combined loss of active elevation and external rotation and underwent concurrent latissimus dorsi transfer and reverse total shoulder arthroplasty, as described by Gerber *et al* (2007).[14]

Clinical and radiological evaluation

Standardized clinical assessment was performed both preoperatively and postoperatively, which comprised of a structured interview, clinical examination, photographic documentation and radiographic evaluation. Patients were also functionally assessed according to the system of Constant and Murley[6] and the results were expressed as absolute point values and also as a percentage of age- and gender-matched normal scores.[11] Strength was measured with the use of a validated electronic dynamometer (Isobex; Cursor, Bern, Switzerland) with the shoulder in neutral rotation and 90° of abduction in the scapular plane. In addition, patients were asked to provide a subjective shoulder value, which is the patient's estimation of his or her shoulder as a percentage of a completely normal shoulder.[12]

At the time of latest follow-up, nine patients were unable to return to our institution for clinical review. These patients underwent detailed phone interviews where they were asked about their subjective shoulder value (SSV), any complications, further surgery or concerns regarding the function of their shoulder. If any complications had resulted and had not been documented by our institution, the patient's family doctor was contacted for further details.

Standardized anteroposterior, axillary lateral and scapular lateral radiographs were obtained under fluoroscopic control in all patients, both preoperatively and postoperatively. Preoperative assessment of the stage of the massive rotator cuff tear was graded according to the Hamada-Walch classification[19; 28] (Table 1). Postoperative radiographs were assessed for component position, radiolucent lines, osteolysis, humeral or glenoid component loosening and the presence of inferior scapular notching. The severity of inferior scapular notching was graded according to Nérot's classification, as described by Sirveaux *et al* (2004).[27]

Statistical analysis

Comparisons of preoperative and postoperative functional scores were performed with the use of independent Student t-tests and subgroup analysis was conducted with the Kruskal Wallis test. Survival curves were generated using the Kaplan-Meier technique. A p value of <0.05 was considered significant. All statistical analyses were performed using IBM SPSS® statistics software (version 20.0, Chicago, Illinois).

RESULTS

Complications

One or more complication occurred in fifteen of the forty shoulders (37.5%). These are summarized in Table 3. In total there were six failures (15%) that resulted in either removal of the prosthesis or conversion to hemiarthroplasty (Delta I™, Depuy, France). Three were for infection that led to prosthesis removal and insertion of a cement spacer and three shoulders were converted to a hemiarthroplasty for glenoid component loosening. There were two postoperative nerve palsies, one affecting the radial nerve and the other involving the brachial plexus. Both patients were managed conservatively patients and regained full function and sensation within six and twelve months, respectively.

Reoperations, revisions and failures

The presence of prior surgery did not seem to affect the complication rate. On the contrary, for patients that had not had prior surgery, the complication rate was 47% (8 of 17) as opposed to 30% (7 of 23) in those who had a least one or more previous operation ($p = 0.15$). Eleven shoulders (27.5%) required at least one reoperation following implantation of their RTSA and of these, ten shoulders (25%) required revision surgery where there was either partial or total exchange of the components or the prosthesis was converted to hemiarthroplasty or removed.

A total of seven patients (17.5%) had a dislocation of their shoulder prosthesis. In two, the dislocations occurred early and both underwent initial closed reduction and subsequent early revision of the polyethylene liner with addition of an epiphyseal extension to optimize soft tissue tension. One patient experienced a dislocation at 50 months, which was treated with closed reduction and no further instability events ensued. In another patient, the polyethylene

liner dislocated at 64 months, requiring liner revision and exchange of the glenosphere due to severe metallosis. Following this, a deep infection developed necessitating single stage debridement, lavage and exchange of the polyethylene liner. The infection was successfully treated with antibiotics and the outcome has been excellent.

Four patients developed symptomatic medial-sided polyethylene wear, with three of these patients presenting as recurrent dislocations. One patient complained of impingement-type pain with shoulder adduction and demonstrated grade 3 infrascapular notching on radiographs. All four patients were managed with revision of the polyethylene liner and addition of an epiphyseal augment. However, two patients redislocated and were subsequently treated with revision of the humeral component in one patient and conversion to a hemiarthroplasty in the other.

There was one traumatic periprosthetic humeral fracture, which was treated with open reduction and internal fixation (ORIF) with a long locking plate. Three patients developed fractures involving the scapula spine, two were the result of a fall and one was considered to be a fatigue fracture. Two required ORIF, with one patient also being converted to a hemiarthroplasty due to extension of the fracture to the glenoid component leading to significant loosening. One patient was successfully treated conservatively. Two other patients had glenoid component loosening, in addition to the one previously mentioned. Both patients were converted to a hemiarthroplasty. In one patient it was suspected that the glenoid loosening was secondary to a low-grade infection, as she had previously undergone a two-stage revision of her reverse prosthesis 7 years prior for deep infection (discussed below). However, intraoperative biopsies at the time of conversion did not identify any organism. The other patient with glenoid loosening had severe ankylosing spondylitis with a significant

kyphotic deformity of the thorax. At the time of revision to hemiarthroplasty, intraoperative biopsies were also taken and infection was excluded.

Deep infections were recorded in five cases (13%), all occurring after a reoperation for a complication. Of these, four occurred after revision of the polyethylene liner for instability, and one case after ORIF of a periprosthetic humeral fracture. Only two of the five patients had had prior surgery before their RTSA. In one case, the management comprised of a single aggressive debridement, change of the liner and intravenous antibiotics. One patient had a two-stage revision, with insertion of a temporary antibiotic-impregnated cement spacer and reimplantation of the RTSA after 7 months. In three patients, the prosthesis was removed and a cement spacer implanted. At latest follow-up, all three had been left *in situ*, as these patients have declined further surgery due to satisfactory and acceptable functional status.

One patient had persistent loss of external rotation with both shoulder abduction and in the neutral position, consistent with an absent teres minor, which was present prior to the RTSA. He underwent a modified L'Episcopo procedure[3] (transfer of latissimus dorsi and teres major tendons) at 132 months (11 years) after his original surgery and this provided him an excellent clinical result (Figure 1).

Clinical results

After excluding the six patients (15%) who had a hemiarthroplasty or removal of the prosthesis as described above, overall there was statistically significant improvement in both functional outcome and also subjective shoulder value at latest follow up. Table 4 summarizes the preoperative and postoperative results, with subgroup analysis of patients who had not had any prior surgery (Group A) and those who have had at least one prior operation (Group B).

Overall, the mean relative Constant score increased from 34% preoperatively to 74% postoperatively, representing a gain of 40% ($p < 0.0001$). The SSV improved approximately three-fold from 23% to 66% (gain of 43%, $p < 0.0001$). The average Constant pain score increased from 5.9 to 12.7 points (gain of 6.8 points, $p < 0.0001$). There were marked improvements in shoulder strength, with the average Constant strength score increasing from 0.8 to 4.6 (gain of 3.8 points, $p < 0.0001$) overall. Active forward elevation improved from 72° to 119° (gain of 47°, $p < 0.001$), active abduction from 67° to 112° (gain of 45°, $p < 0.001$) and active external rotation remained similar from 27° to 26° ($p = 0.86$). As shown in Table 4, there was no significant difference in clinical outcome between patients who had no prior surgery (Group A) compared with those who had at least one operation before their RTSA (Group B). In addition, we did not observe any significant difference in functional outcome ($p = 0.18$) and SSV ($p = 0.09$) between patients who did not have glenohumeral arthritis preoperatively (Hamada-Walch stages 1 to 3) and those who did (Hamada-Walch stages 4 and 5).

Of the patients that had developed a complication that was subsequently managed without conversion or removal of the prosthesis (9 shoulders), the mean relative Constant score at latest follow-up was 74%, which was identical to the mean score of those patients who had no complication ($p = 0.5$). The SSV was also similar in both groups, with a mean score of 67% in the complication group compared to 65% in the non-complication group ($p = 0.43$) (Figure 2). In addition, there was no statistical difference with respect to pain, strength or active range of movement between the two groups.

With the numbers available, analysis of the clinical results and SSV over time was also performed. We found no significant functional deterioration over ten years, with the relative

Constant score and SSV remaining above 70% and 60%, respectively at 2 to 5 years, 5 to 7 years and 7 to 10 years (Table 5).

Radiographic outcome

At latest follow-up, there were no cases of glenoid component or humeral stem loosening. Notching of the infrascapular neck was observed in 56% of cases overall, with the majority of patients having either Stage 1 (24%) or Stage 3 (21%) notching. Over time, we found that the prevalence and the degree of notching increased, as shown in Table 6. In terms of the relationship between notching and functional outcome, we observed a significant difference in relative Constant scores between those who had no notching and that did (85.6% vs. 65.6%, p=0.02).

Survival analysis

Survival analysis was performed for 1) reoperation for any complication and for 2) failure for any reason leading to removal of the prosthesis or conversion to hemiarthroplasty (Figure 3). With removal or conversion to hemiarthroplasty as an endpoint, the overall implant survival rate was 98% at 5 years (60 months) and 88% at 10 years (120 months). With reoperation for any complication as an endpoint, the overall survival rate was 88% at 5 years (60 months) and 76% at 10 years (120 months).

DISCUSSION

The treatment of the young and active individual with painful dysfunction of the shoulder secondary to a massive irreparable rotator cuff tear with or without glenohumeral arthritis remains a significant challenge. The main aim of management in the younger patient is to preserve the native joint prior to considering any salvage arthroplasty. Whilst latissimus dorsi transfer has shown to significantly benefit patients with irreparable posterosuperior rotator cuff tears, this operation does not appear beneficial in patients who have a deficient subscapularis or those who have developed glenohumeral arthritis or chronic pseudoparalysis of elevation.[1; 13] As such, currently the only reliable option available for these patients has been the RTSA, however its role in the young and active patient remains unclear.[4; 29; 30]

All patients in our series presented with severe functional impairment of their shoulder, having exhausted all forms of non-operative measures prior to surgery.[16] All had high functional demands and were unwilling to accept their current level of disability. Twenty-three patients (58%) had undergone at least one previous operation, with the large majority having failed previous attempts at rotator cuff repair. The degree of dysfunction prior to RTSA was reflected in a low mean relative Constant score (34%) and an extremely low SSV (23%). Improvement of over 40% for both the relative Constant Score and SSV after a mean follow-up of 93 months is consistent with other studies of RTSA in older patients.[2; 4; 29; 32] Interestingly, we found no significant difference in clinical outcome between patients who had at least one prior surgery and those who had not, provided that no complication had occurred which would have required removal of the RTSA. This is in contradiction to previous studies by Boileau *et al* (2009) and Werner *et al* (2005) who both showed poorer results of RTSA after previous cuff surgery.[2; 30]

Longevity of the prosthesis is a major concern in younger patients, hence in this study we only reported on the results of patients who have had at least five years of follow-up. Favard *et al* (2011) showed, in a population with a mean age of 73 years, that the relative Constant score deteriorated from 88% at less than 5 years to 78% at follow-up greater than 9 years.[9] Furthermore, survivorship with an absolute Constant score less than 30 points as an endpoint was 72% at 10 years, with a break at approximately 8 years. Guery *et al* (2006) demonstrated similar results in terms of function, with a survivorship of 58% at 10 years. The reason for this clinical deterioration is unknown.[18] Favard *et al* (2011) postulated that this may reflect the delayed consequences of radiographic signs of potential failure, however this has not been confirmed.[9] In our study, we found no significant change in both the functional scores and SSV over a 10-year period. While this may reflect the relatively young age of our study group, it may also be due to the fact that several of our patients have undergone revision surgery for a complication, and as a result this had improved any potential cause for a lower functional outcome and SSV.

Another concern with the RTSA is the relatively high reported complication rate, which ranges from 19% to 50%.[29; 30; 32] In a large meta-analysis of current literature performed by Zumstein *et al* (2011), adverse outcomes were divided into problems and complications based on their affect on patient outcome.[32] They reported that the overall rate of postoperative problems following reverse shoulder arthroplasty was 44% and the incidence of complications was 24%. Based on this distinction, in our study, one or more complication occurred in fifteen of the forty shoulders (37.5%). In six patients (15%), this necessitated removal of the prosthesis or conversion to a hemiarthroplasty. Dislocation of the prosthesis was the most common complication in this present series, with early dislocation being associated with the need of revision, whereas late dislocation was successfully treated with

closed reduction unless it was associated with advanced medial-side polyethylene wear. There were five deep infections in our series, all of which occurred following a reoperation for a complication. Four of these occurred following revision of the polyethylene liner for instability. This confirms that the infection rate is higher following revision RTSA than in primary surgery.[4; 7; 22; 30] However, in our study, the reason for this high infection rate is unclear and one might consider it prudent to obtain intraoperative biopsies in all revision surgeries. In the five patients that developed deep infection, three patients required removal of their prosthesis and implantation of a cement spacer. Despite this being a salvage procedure, all three patients reported acceptable functional outcome and refused further revision was considered. [25]

Notwithstanding the high complication and reoperation rate, we found that in those patients who had developed a complication that did not ultimately lead to removal of the prosthesis or conversion to hemiarthroplasty (9 of 15 patients), the functional outcome and subjective shoulder value were similar to those patients that had not experienced a complication. As the causes for prosthetic failure in our series were deep infection (3 patients) and glenoid base loosening (3 patients), our results demonstrate that management of complications other than these can be performed successfully without compromising patient's function and satisfaction.

In our series, scapular notching was observed in 56% of cases at the time of latest follow-up. In addition, we observed that both the incidence and degree of notching increased over time, which is consistent with other published studies.[9; 21; 23] The clinical significance of infrascapular notching is still unclear and it has been suggested that it may be contributory to glenoid component loosening.[21; 24; 27] However, in our study, we did not observe any significant notching in the three patients that developed this complication, with all three

showing only grade 1 changes. On there other hand, the functional outcome was significantly better in those patients that did not have any notching compared to those that did (85.6% vs. 65.6%, p=0.02), which is in keeping with previous works.[21; 26]

CONCLUSION

To date, there are no mid to long-term studies of RTSA in patients less than 65 years age for the treatment of massive irreparable rotator cuff tears with or without glenohumeral arthritis. This study shows that the use of the RTSA in this unusually unfavorable cohort yields excellent results at no less than 10 years, provided that complications, which require removal of the prosthesis, can be prevented. We have demonstrated that it reliably provides significant improvement in overall function and patient satisfaction in the mid to long-term. Although the complication rate is high, most of these can be treated successfully without substantial compromise to clinical outcome. However, it is imperative that the high complication and reoperation rate is discussed in depth with the patient, with analysis of risk versus benefit clearly and carefully considered prior to surgery.

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FIGURE LEGEND

Figure 1. Clinical and radiological results after 15 years in a patient who underwent a reverse total shoulder arthroplasty at the age of 57 years for a massive irreparable rotator cuff tear with chronic pseudoparesis. **(A)** Preoperative anteroposterior and axillary lateral radiographs demonstrating superior migration of the humeral head combined with mild degenerative changes of the glenohumeral joint consistent with a massive irreparable rotator cuff tear. **(B)**, **(C) and (D)** Clinical photographs showing preoperative pseudoparesis of anterior elevation, abduction and external rotation. Note that with attempted elevation of the shoulder, the arm falls into interal rotation which is consistent with a deficient infraspinatus and teres minor. **(E)** Postoperative anteroposterior and scapular lateral radiographs at 15 years showing grade 3 scapular notching with no radiographic signs of loosening. **(F), (G) and (H)** Clinical photographs demonstrating restoration of active forward elevation, abduction and external rotation after reverse total shoulder arthroplasty and subsequent latissimus dorsi/teres major tendon transfer.

Figure 2. Preoperative and postoperative mean relative Constant scores and subjective shoulder values for all shoulders, those with no complication (n=25) and those who had at least one complication (n=9).

Figure 3. **(A)** Kaplan-Meier survivorship curves, with reoperation for any complication as the end point. **(B)** Kaplan-Meier survivorship curves for failure of the reverse total shoulder arthroplasty, with removal of the prosthesis or converion to a hemiarthroplasty as the end point.

Table 1: Staging of massive rotator cuff tears and number of patients with or without previous surgery

	No. (%)
Staging of massive rotator cuff tears (Hamada-Walch)[19,28]	
Grade 1 (AHI ≥ 6mm)	13 (33%)
Grade 2 (AHI < 6mm)	5 (13%)
Grade 3 (AHI < 6mm with acetabularization)	3 (8%)
Grade 4a (glenohumeral arthritis without acetabularization)	7 (18%)
Grade 4b (glenohumeral arthritis with acetabularization)	4 (10%)
Grade 5 (collapse of humeral head, "cuff tear arthropathy")	8 (20%)
Group A – no previous surgery	17 (43%)
Group B – previous surgery	23 (57%)

AHI = acromiohumeral distance

Table 2: Previous failed surgery

	No. (%)
One previous operation (n=16)	
Rotator cuff debridement	14 (61%)
Failed rotator cuff repair	1 (4%)
Latissmus dorsi tendon transfer	1 (4%)
Two previous operations (n=3)	
Rotator cuff repairs (2)	2 (9%)
Shoulder arthroscopy (1) and cuff repair (1)	1 (4%)
Three previous operations (n=1)	
Rotator cuff repairs (2) and cuff debridement (1)	1 (4%)
Four previous operations (3)	
Rotator cuff repairs (2) and acromioplasty (2)	1 (4%)
Rotator cuff repair (1) and cuff debridements (3)	1 (4%)
Rotator cuff repair (1), deltoid flap (1), osteotomy of acromion (1), removal of metalware (1)	1 (4%)

	No.	Definitive treatment
Postoperative nerve palsy	2	Conservative management (n=2)
Soft tissue impingement	1	Arthroscopic debridement of scar tissue in subacromial space (n=1)
Scapula fracture	3	Conservative treatment (n=1; 14 months), ORIF (n=1; 81 months) ORIF and conversion to hemiarthroplasty* (n=1; 130 months)
Periprosthetic humeral fracture	1	ORIF (n=1; 72 months)
Early dislocation (< 6 weeks)	2	Change of liner and cup extension (n=2)
Late dislocation	5	Closed reduction only (n=1; 50 months) Change of liner and cup extension (n=2; 35 & 64 months) Conversion to hemiarthroplasty** (n=1; 93 months) Revision of humeral component and liner change (n=1; 35 months)
Polyethylene wear	1	Change of liner and cup extension (n=1; 18 months)
Glenoid component loosening	3	Conversion to hemiarthroplasty (n=3; 76, 89 & 130* months)
Infection	5	Debridement, change of liner and antibiotics (n=1; 64 months) Removal of prosthesis and cement spacer (n=3; 29, 94** & 120 months) Temporary spacer and reimplantation of RTSA (n=1; 5 months)

*same patient, fracture extended to glenoid component resulting in loosening;

** same patient, this patient later had removal of prosthesis and a cement spacer because of infected hemiarthroplasty

ORIF = open reduction internal fixation, RTSA = reverse total shoulder arthroplasty

Table 4: Preoperative and Postoperative functional scores for shoulders with no previous surgery (Group A) and shoulders with previous surgery (Group B)

	Preoperative	Postoperative	Gain	P value
Relative Constant score (%)				
All shoulders	34 ± 16 (11-74)	74 ± 24 (31-100)	+40	<0.0001
Group A	35 ± 15 (11-67)	69 ± 28 (31-100)	+34	<0.0001
Group B	33 ± 16 (12-74)	77 ± 21 (40-100)	+44	<0.0001
Absolute Constant score (points)				
All shoulders	27 ± 13 (10-67)	57 ± 20 (22-87)	+30	<0.0001
Group A	27 ± 10 (10-56)	53 ± 22 (22-83)	+26	<0.0001
Group B	28 ± 14 (10-67)	60 ± 18 (22-87)	+32	<0.0001
Constant score for pain				
All shoulders	5.9 ± 4.1 (0-15)	12.7 ± 3.3 (5-15)	+6.8	<0.0001
Group A	5.3 ± 3.7 (0-13)	14 ± 2 (10-15)	+9.7	<0.0001
Group B	6.5 ±4.4 (0-15)	13 ± 3 (5-15)	+6.5	<0.0001
Constant score for strength				
All shoulders	0.8 ± 1.9 (0-6)	4.6 ± 5.6 (0-16)	+3.8	<0.0001
Group A	0.4 ± 1.5 (0-6)	5.0 ± 5.5 (0-15)	+4.6	<0.0001
Group B	1.2 ± 2.1 (0-6)	4.1 ± 5.8 (0-16)	+2.9	<0.0001
Subj shoulder value** (%)				
All shoulders	23 ± 16.4 (0-80)	66 ± 28 (0-100)	+43	<0.0001
Group A	25 ± 13 (0-40)	61 ± 34 (0-100)	+36	<0.0001
Group B	21 ± 19 (0-80)	68 ± 25 (20-100)	+47	<0.0001
Active forward flexion (deg)				
All shoulders	72 ± 38 (30-170)	119 ± 34 (50-160)	+47	<0.001
Group A	78 ± 27 (40-130)	109 ± 45 (50-160)	+31	<0.0001
Group B	68 ± 45 (30-170)	126 ± 26 (75-160)	+58	<0.0001
Active abduction (deg)				
All shoulders	67 ± 37 (30-170)	112 ± 39 (45-165)	+45	<0.0001
Group A	65 ± 28 (30-130)	98 ± 44 (45-150)	+33	<0.0001
Group B	69 ± 43 (30-170)	120 ± 34 (55-165)	+51	<0.0001
Active ext. rotation (deg)				
All shoulders	27 ± 27 (-20-90)	26 ± 20 (-30-60)	-1	NS
Group A	18 ± 21 (-15-70)	23 ± 23 (-30-50)	+5	NS
Group B	35 ± 30 (-20-90)	28 ± 19 (0-60)	-7	NS

Postoperative data excludes patients that have had removal or conversion of their prosthesis and those who have had phone interviews. All shoulders (preop n=40, postop n=26), Group A (preop n=23, postop n=10); Group B (preop n=17, postop n=16).
**Postoperative subjective shoulder value includes patients who were interviewed by phone, Group A, n=11, Group B, n=21.
NS = not significant,

Table 5: Preoperative and postoperative clinical results

	2-5 years	5-7 years	7-10 years	*p* value
Number of shoulders	29	26	8	
Relative Constant score (%)	73 ± 23	70 ± 25	77 ± 20	0.80
Absolute Constant score (points)	57 ± 18	55 ± 19	59 ± 17	0.87
Pain	12 ± 3	13 ± 3	11 ± 4	0.25
Strength	5.8 ± 4.9	4.1 ± 4.8	6.4 ± 6	0.25
Subjective shoulder value** (%)	61 ± 25	62 ± 26	66 ± 30	0.93
Range of motion (degrees)				
Active forward flexion	122 ± 33	106 ± 43	122 ± 22	0.59
Active abduction	114 ± 36	98 ± 42	118 ± 30	0.44
Active external rotation	24 ± 22	23 ± 26	13 ± 27	0.47

Table 6: Degree of infrascapular notching at latest follow-up and with increasing time

Notch stage	< 1 year	2-5 years	5-7 years	7-10 years	Latest follow-up
No Notching	17 (57%)	15 (54%)	11 (39%)	2 (22%)	15 (44%)
Stage 1	8 (27%)	7 (25%)	6 (21%)	0 (0%)	8 (24%)
Stage 2	3 (10%)	2 (7%)	4 (14%)	2 (22%)	3 (9%)
Stage 3	2 (7%)	3 (11%)	6 (21%)	4 (44%)	7 (21%)
Stage 4	0 (0%)	1 (4%)	1 (4%)	1 (11%)	1 (3%)
Total number	30	28	28	9	34

Figure 1

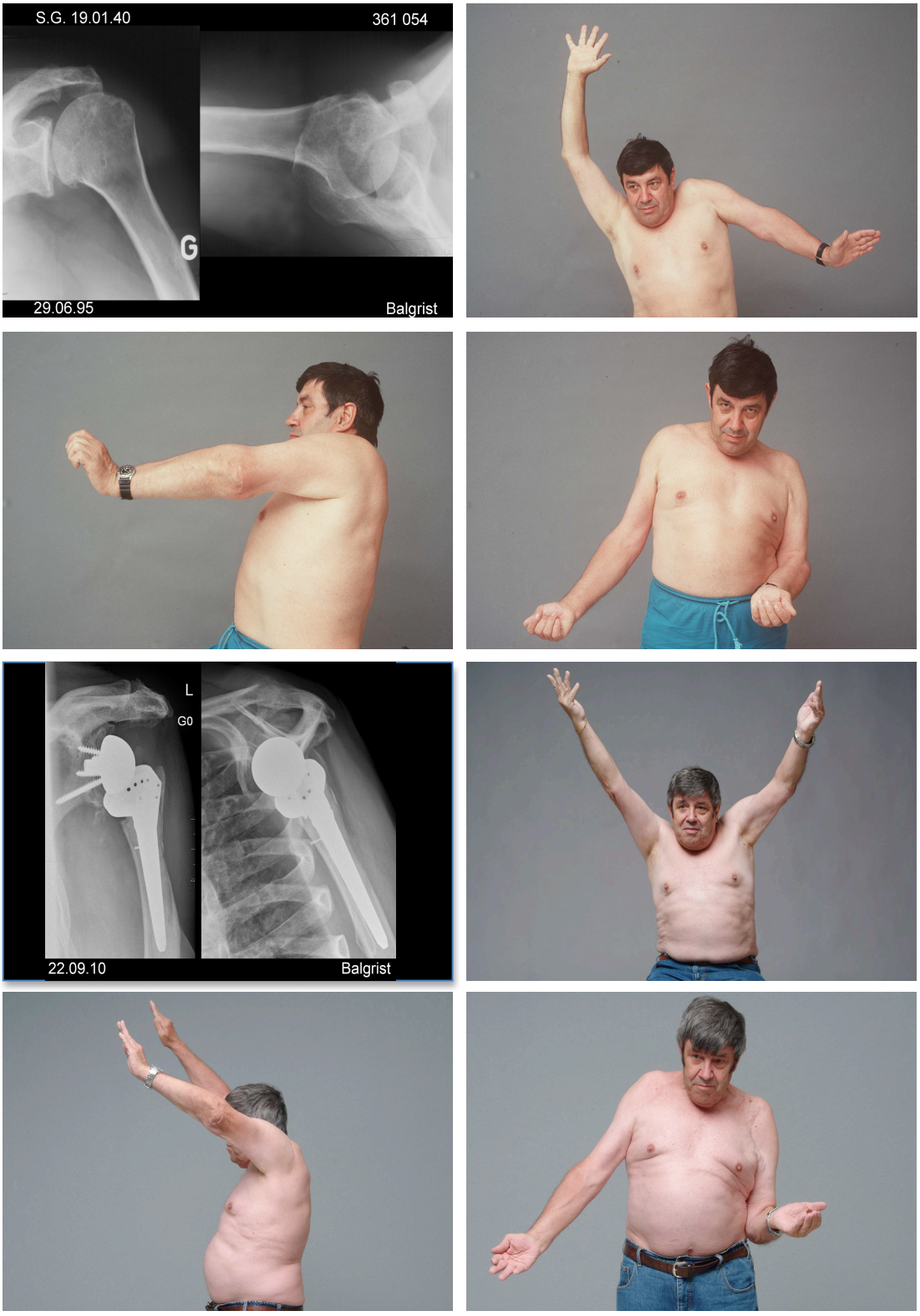


Figure 2

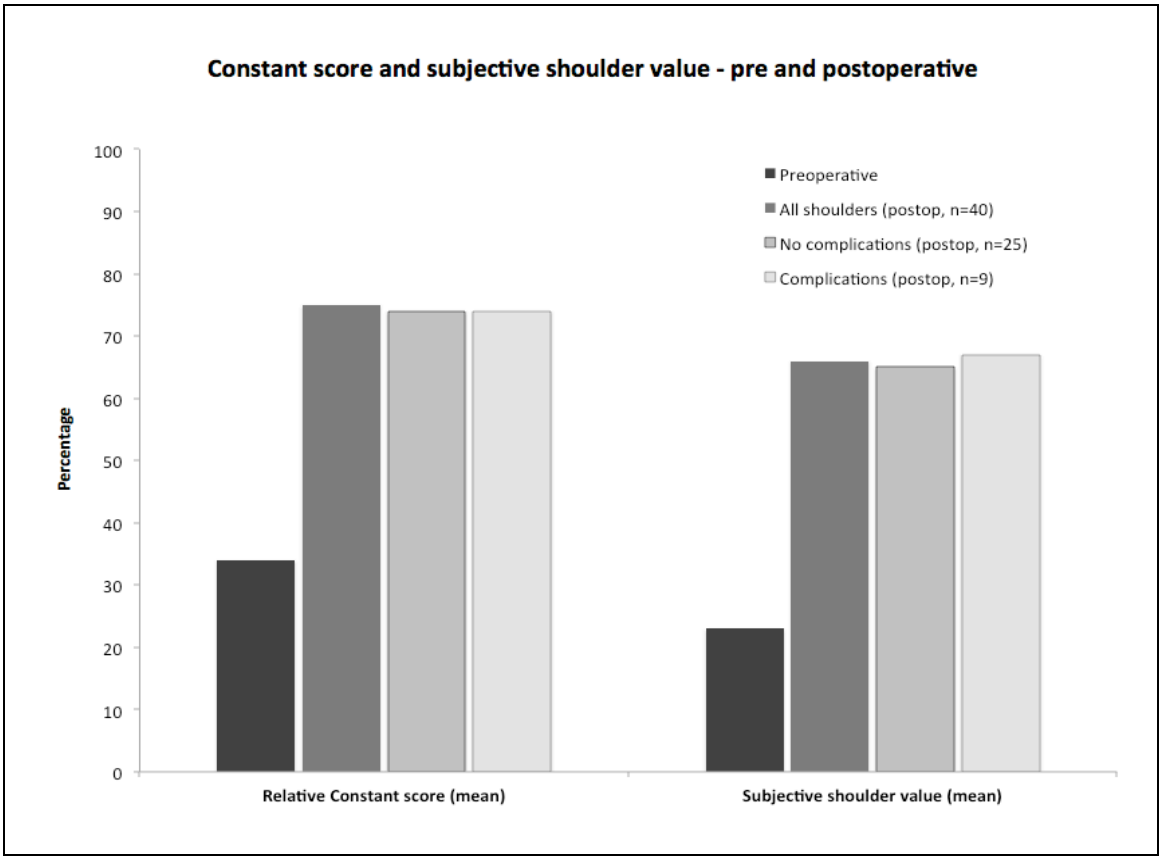
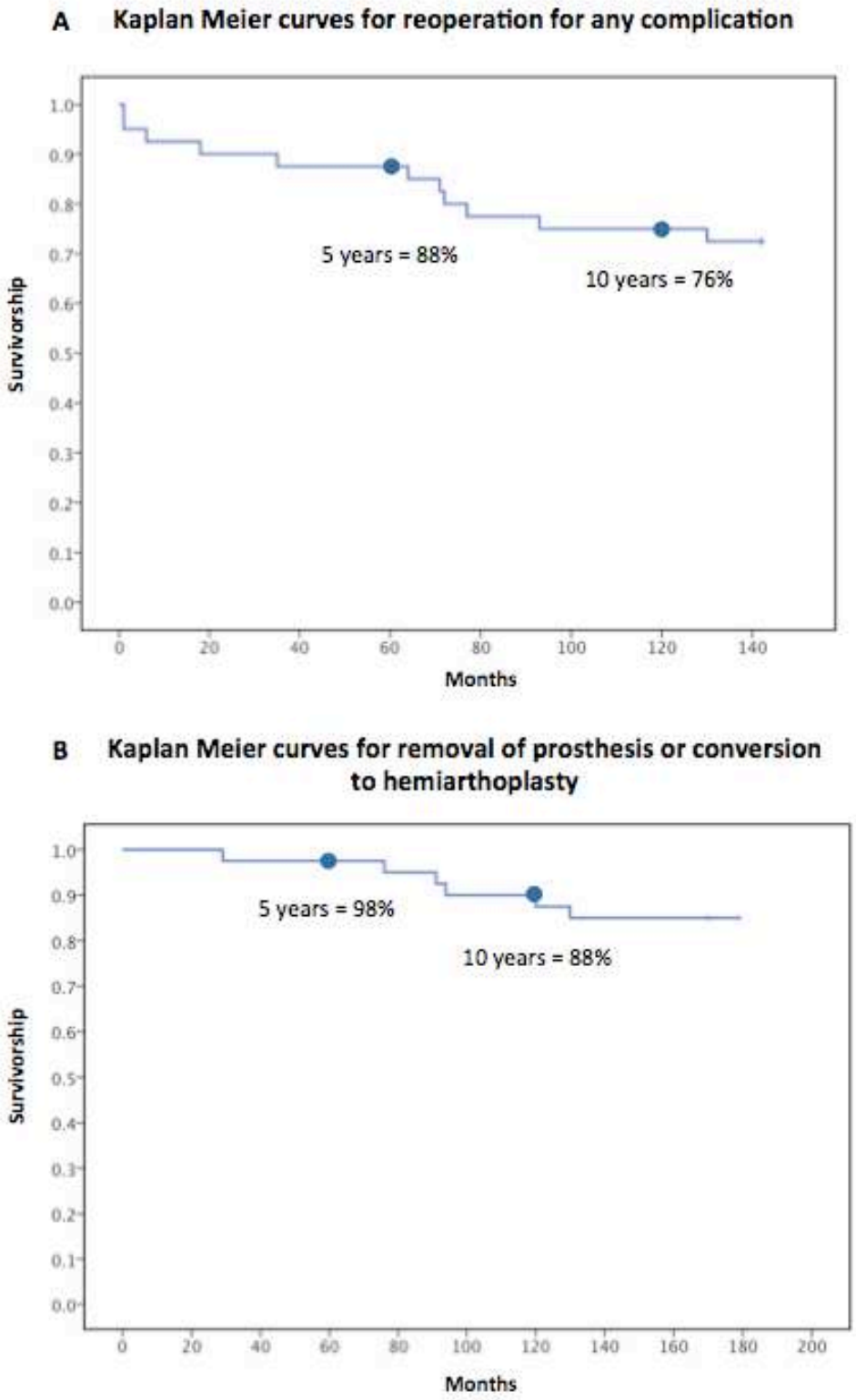

Constant score and subjective shoulder value - pre and postoperative
Percentage
100
90
80
70
60
50
40
30
20
10
0
Preoperative
All shoulders (postop, n=40)
No complications (postop, n=25)
Complications (postop, n=9)
Relative Constant score (mean)
Subjective shoulder value (mean)

Figure 3


A Kaplan Meier curves for reoperation for any complication
Survivorship
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
5 years = 88%
10 years = 76%
0
20
40
60
80
100
120
140
Months
B Kaplan Meier curves for removal of prosthesis or conversion to hemiarthoplasty
Survivorship
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
5 years = 98%
10 years = 88%
0
20
40
60
80
100
120
140
160
180
200
Months